Surface Technologies

Introduction

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Surface Process

- **Surface Modifications**
  - I. Without composition change
  - II. With composition change

- **Surface Coatings**

Surface Mod. I (Without composition change)

- **Mechanical Surface Treatments**
  - Shot peening (bead blasting)
  - Laser shock peening (laser peening)
  - Ultrasonic surface machining
  - Laser surface machining
- **Thermal Surface Treatments**
  - Surface hardening (with flame,induction, electron beam or laser)
  - Surface melting (with laser)

Surface Mod. II (With composition change)

- **Phosphate, chromate, oxide coating**
- **Anodic oxidation (eloxal coating)**
- **Thermochemical Processes**
  - Carburizing, Nitriding, Boriding
- **Ion implantation**
- **Laser alloying**

Surface Coatings

- **Hot dip coating (Galvanizing)**
- **Solid State Process (Cladding)**
- **Enamel Coating**
- **Metal Spray Coatings**
    - *** Thermal Metal Spraying**
        - Flame spraying
        - Electric arc spraying
        - Plasma spraying
        - Deposition with detonation gun (D-gun)
        - High velocity oxy-fuel spraying (HVOF)
        - High velocity air-fuel spraying (HVAF)

Surface Coatings

- **Metal Spray Coatings**
  - *** Cold (Gas) Spraying**
    - Low pressure cold spray (LPCS)
    - High ressure cold spray (HPCS)
- **Coating in a solution**
  - Electro deposition (electro plating)
  - Electroless deposition
- **Coating with sol-gel method**
- **Coating from vapour phase**
  - Chemical vapour deposition (CVD)
  - Physical vapour deposition (PVD)
  - Ion beam asissted deposition (IBAD)

Purpose of Surface Treatments

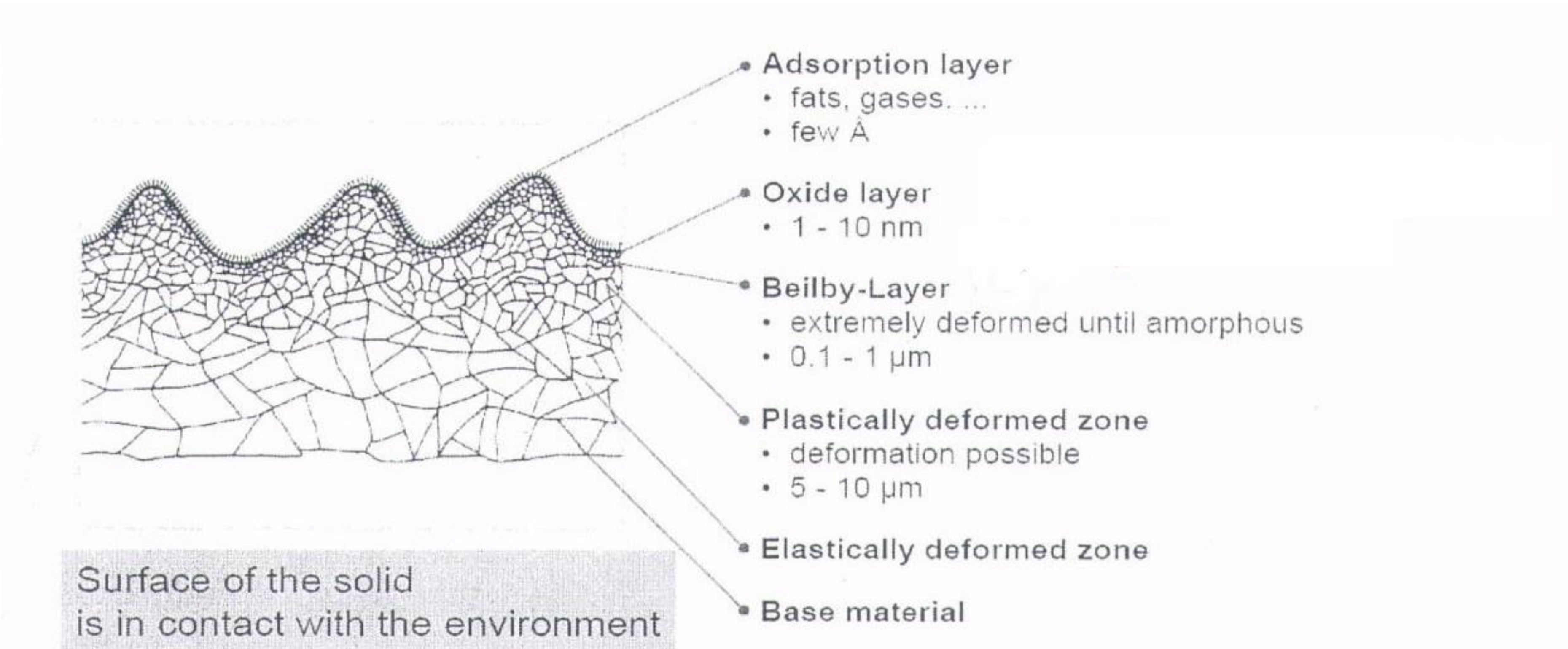
Protect materials against to

- Wear
- Erosion
- Corrosion
- Fatigue
- Oxidation
- High temperature

What is the surface ?

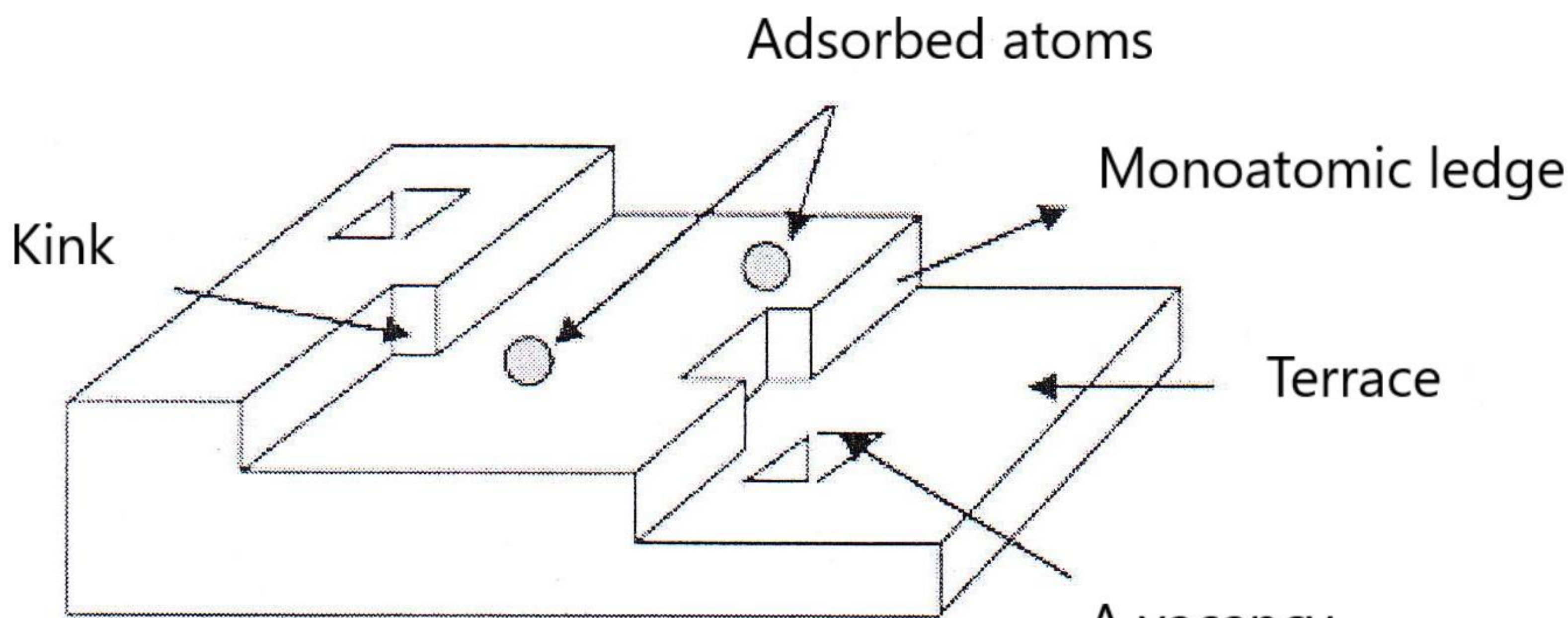
- It can be considered as end of the bulk structure.
- Geometrical boundary between the material and its environment.
- For tribological aspect surface term includes a certain deep through material inside.
- Surface region has microstructural and compositional differences. So this difference region from the bulk structure is called surface.

Structure of a Technical Surface



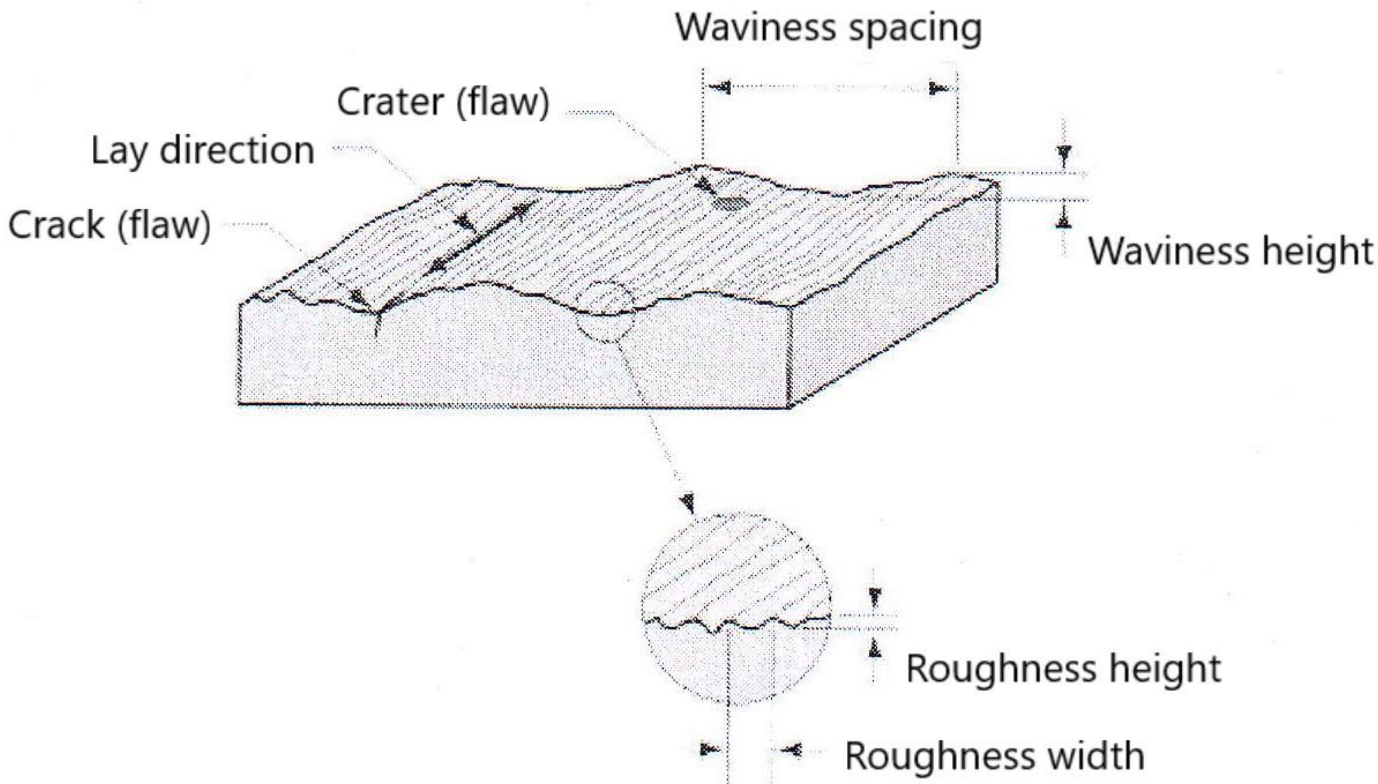
Topographic Structure of Surface

- For defining the topographic structure microstructure and atomic scale structure must be distinguished.
- There can be several planes in atomic scale.
- Terrace (düzlük)-ledge(set)-kink(kıvrım) model

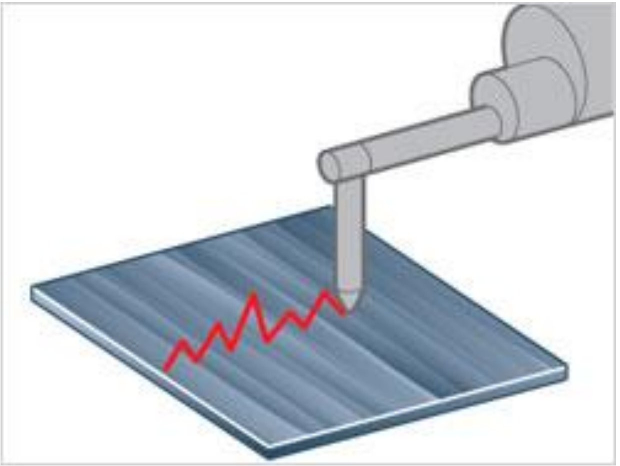


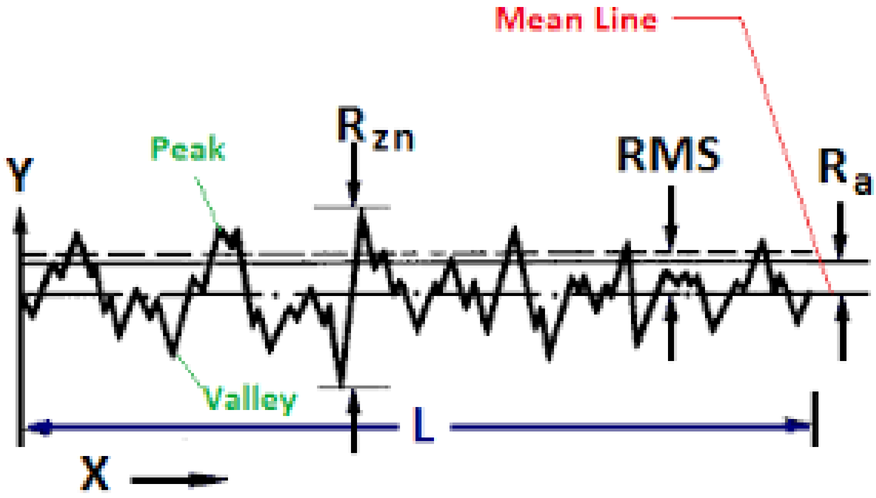
Surface Profile

- The parameter used to quantitatively determine the surface roughness in engineering is Ra (average roughness)



Surface roughness measurement





Surface roughness in engineering practice. Surface roughness design requirements for engineering applications can vary by as much as two orders of magnitude. The reasons and considerations for this wide range include the following:

1. Mating surfaces require different precision. For example, ball bearings and gages require very smooth surfaces and high precision, whereas surfaces for gaskets and brake drums are much rougher.
2. Tribological considerations, including the effects of roughness on friction, wear, and lubrication.
3. Fatigue and notch sensitivity, because rougher surfaces usually have shorter fatigue life.

4. Electrical and thermal contact resistance, because the rougher the surface, the higher its contact resistance.

5. Corrosion resistance, because the rougher the surface, the greater will be the possibility of entrapping corrosive media.

6. Subsequent processing, such as painting and coating, where a certain degree of roughness generally results in better bonding (a phenomenon also called mechanical locking).

7. Depending on the application, a rougher surface may be preferred over a smoother one mainly for aesthetic reasons.

8. Cost considerations, because the finer the surface finish, the higher is the manufacturing cost.

Surface energy

- **Surface free energy** or **interfacial free energy** or **surface energy** quantifies the disruption of intermolecular bonds that occurs when a surface is created.
- In the physics of solids, surfaces must be intrinsically less energetically favorable than the bulk of a material (the molecules on the surface have more energy compared with the molecules in the bulk of the material).
- The surface energy may therefore be defined as the excess energy at the surface of a material compared to the bulk, or it is the work required to build an area of a particular surface.

Contact angle

- A way to experimentally determine wetting is to look at the contact angle (θ), which is the angle connecting the solid–liquid interface and the liquid–gas interface (as in the figure).

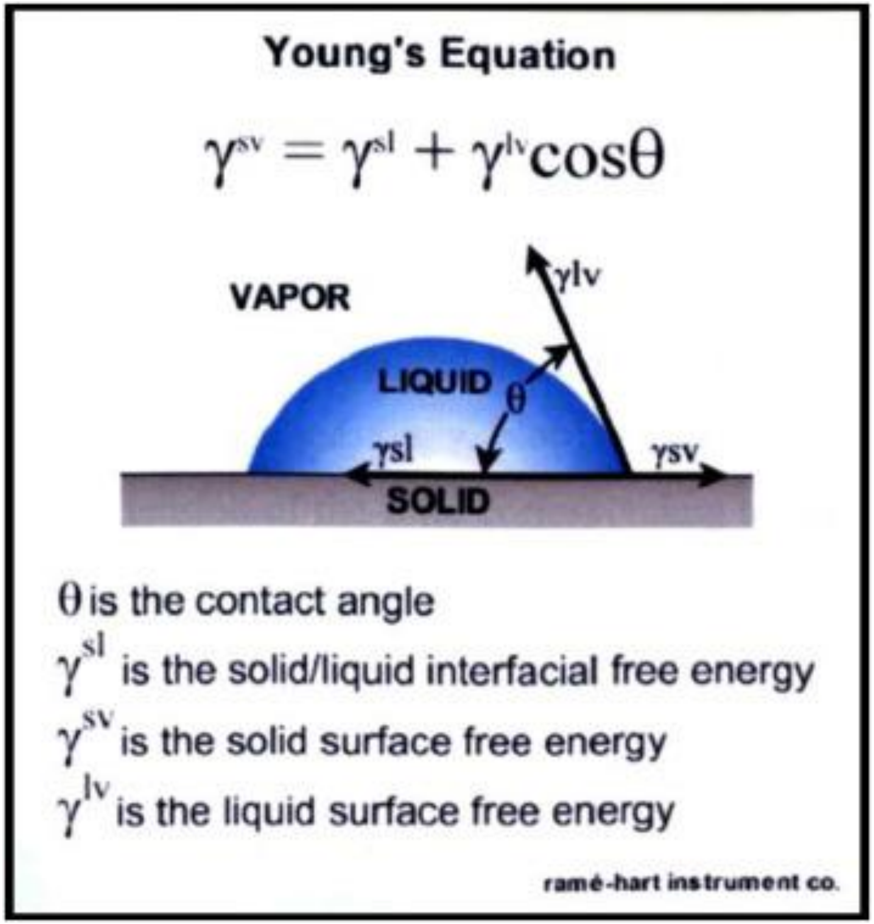
If $\theta = 0°$, the liquid completely wets the substrate.

If $0° < \theta < 90°$, high wetting occurs.

If $90° < \theta < 180°$, low wetting occurs.

If $\theta = 180°$, the liquid does not wet the substrate at all.

- The Young equation relates the contact angle to interfacial energy:


Young's Equation
$\gamma^{sv} = \gamma^{sl} + \gamma^{lv}\cos\theta$
VAPOR
γlv
LIQUID
θ
γsl
γsv
SOLID
θ is the contact angle
γ^{sl} is the solid/liquid interfacial free energy
γ^{sv} is the solid surface free energy
γ^{lv} is the liquid surface free energy
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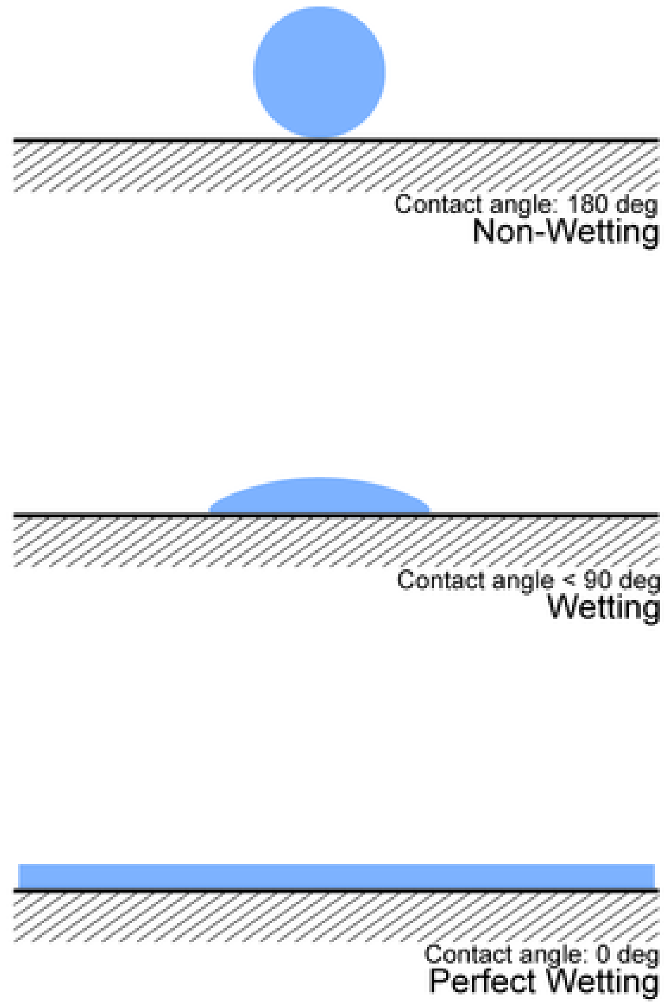
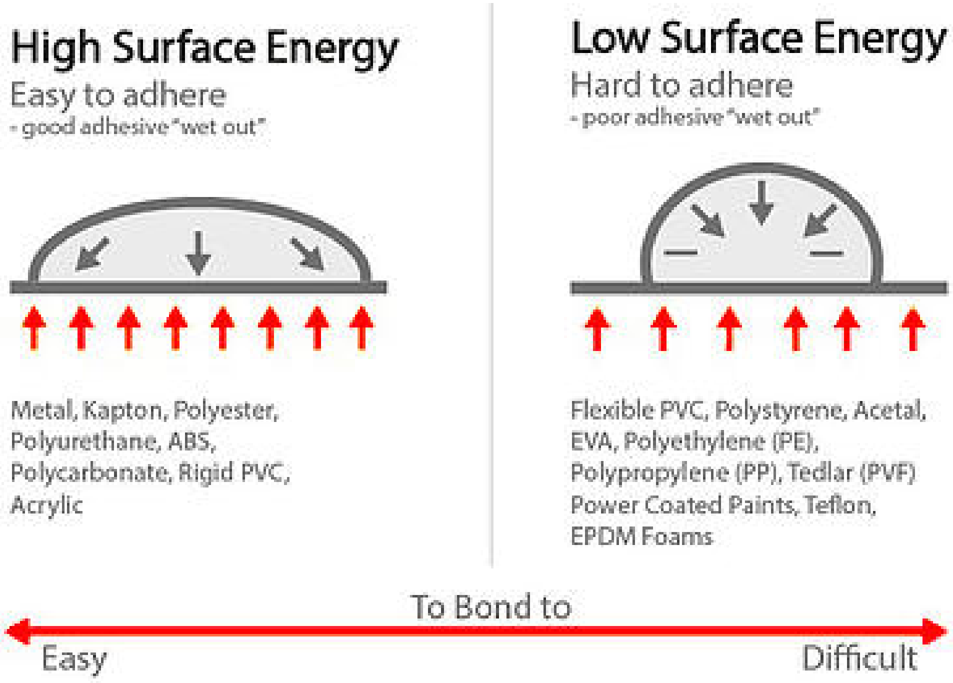

Contact angle: 180 deg
Non-Wetting
Contact angle < 90 deg
Wetting
Contact angle: 0 deg
Perfect Wetting

The energy of the bulk component of a solid substrate is determined by the types of interactions that hold the substrate together. High-energy substrates are held together by bonds, while low-energy substrates are held together by forces. Covalent, ionic, and metallic bonds are much stronger than forces such as Van der Waals and hydrogen bonding. High-energy substrates are more easily wetted than low-energy substrates.



Desired properties from bulk material

- Mechanical strength
- Fatigue resistance
- Ductility
- Hardness
- Conductivity
- Thermal expansion

Desired properties from surface

- Aesthetical appearance
- Wear and friction resistance
- Corrosion resistance
- Fatigue resistance
- Hardness
- High temperature resistance
- Optical and thermal interactions
- Anti-wetting ability
- Conductivity
- Semi-conductivity
- Superconductivity

Desired properties from surface

- Insulation
- Piezoelectrical
- Magnetic
- Optical
- Optoelectronic
- Piroelectric
- Biocopatible
- Thermal